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VARIAN ENGINEERING
REPORT NO. 102-8

COPY NO. 2
MARCH 1953

MILITARY APPLICATIONS

OF

NUCLEAR RESONANCE FILTERS

Status Report For 1 Aug thru 31 Oct 1952

Prepared for

OFFICE OF NAVAL RESEARCH
Contract NOnr-523(00)

by

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53AA-7534

GENERAL PURPOSE

Under the terms of the contract Varian Associates shall conduct research on military applications of nuclear resonance filters. This work includes, but is not necessarily limited to, the following:

1. Experimental demonstration of the idea to show in the simplest manner that the nuclear induction filter works.

2. A detailed theoretical study of the physics of the problem.

3. An analysis of the behavior of the nuclear induction filter as a new type of filter element.

PROGRESS

Probe Design and Construction

The Mark III probe has been tested for several weeks. The electrical design of this probe is quite similar to that of Mark II; the transmitter field is produced by a short, balanced transmission line which is tuned by a capacitor on each end. The two-turn receiver coil is located inside the center of this transmitter line, and the proton sample is within the receiver coil where it is coupled to both the transmitter and the receiver, although the latter two are not mutually coupled.

The mechanical construction of this probe was partially described in a previous report (Varian Engineering Report No. 102-5). The body was

machined from a split block of aluminum, and the smooth mating surfaces greatly reduced the leakage between cavities, as well as the coupling between the inside and the outside of the probe. The amount of this leakage proved to be so small that no metal gaskets were required. The transmitter line was mounted on split halves of precision-bore, glass tubing. In an attempt to use metal lines plated onto the glass, an even thin layer of silver was sprayed onto the area to be plated, and after the paint had dried and had been baked, a heavy plating of copper was added. However, the r-f loss of this plated line proved to be high as compared to pure copper, and this first glass line was discarded. The present line was made by cementing .002-inch copper strips to the glass by means of a thermosetting plastic. These copper-on-glass lines are tuned by compression-type mica condensers, which are assembled in such a manner that symmetry inside the line is continued to the centerline across the ends. The transmitter power is delivered through a balanced 95 ohm line which divides inside the probe and feeds one conductor of the tuned line on its two ends. The other side of this tuned line is grounded at its mid-point by a small metal tube which also acts as a shielded duct for the receiver coil leads. The impedance at the feed points is approximately 200 ohms when the line is tuned to 30 mc. The balance of the transmitter tuned circuits to ground is adjusted by means of a tunable 7 to 35$\mu\mu$f condenser from one lead of the 95 ohm transmitter feed line to ground.

The receiver coil is wound into a groove around a lucite capsule. This capsule is constructed so that the receiver coil is coupled very closely to the liquid inside. The rubber O-ring that fits over the receiver coil

winding forms a tight fit inside the tuned transmitter line when the latter is in place inside the probe. This rubber ring acts both as a centering guide and as a fulcrum for tilting of the capsule and receiver coil assembly for v-mode leakage balance. The tuned receiver coil has an impedance of 2850 ohms at 30 mc.

The u-mode of leakage is controlled by a resistance loop. This loop consists of two turns of resistance wire in series, mounted at right angles to each other on a lucite cylinder. One turn couples loosely to the receiver coil; the other turn has variable coupling to the transmitter when this loop is rotated.

Tuning of Probe

The tuning procedure for the Mark III probe is similar to that of the Mark II with the end result about the same, except that the later model is easier to balance and is much more stable.

The order of tuning is important because each control has an effect on tuning and balance. First the receiver and transmitter sections are tuned to 30 mc. Either a sweep generator or a pulsed generator can be used for a signal, since techniques for balancing with either type have been devised. After transmitter and receiver sections are tuned, the v-mode control is turned until a minimum output is indicated. The quadrature (v-mode) control has limited range and may not balance until the correct setting of the transmitter line condensers is approached. In general, it is only necessary to find both the correct setting of these line condensers and

the optimum position of the condenser on the transmitter feed line in order to obtain the balance that is least sensitive to frequency This is actually a laborious task, because the moving of one control changes the setting of three other interlocking controls. By proceeding in the right order, this initial adjustment can be completed in one to two hours, and after that rather simple corrections will keep the probe in balance.

Performance

It has been demonstrated repeatedly that the probe can be adjusted so the direct leakage is at least 40 db less than the nuclear coupling over a 100 kc band. In order to pass a shorter pulse, the gradient of the magnetic field was increased to give approximately a 200 kc bandpass. The balance for the increased bandwidth is normally more critical; nevertheless, a balance to 20 or 30 db below the signal is adequate and obtainable.

One of the main causes of probe instability is the temperature changes of the probe. The time constants of these changes can vary from less than a second to hours. An example of a short time instability is a condition in which a high power 40μsec pulse could not be balanced over its entire length. This was traced to the use of silver paint for the resistive conductor in the u-mode leakage control. Apparently, the silver paint was being heated during the pulse. When it was replaced by a fine resistance wire, this trouble was eliminated. Long time drift can be caused by a physical change in the probe. Some temperature compensations were used in the construction, but the immediate problem was reduced by installing the magnet (with probe) inside a temperature controlled box.

At the present time, the probe has a thermal dri change, which is only noticeable when the average power i 0.1 watt level. The time constant of this change is appr

This Mark III probe has been taken apart and re- times with only slight changes in performance characteris used in many tests and, although the temperature and oth are troublesome, it is a satisfactory and useful tool in evaluate the properties of the nuclear resonance filters.